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groundwater management strategy for michigan

Development of Administrative Rules for Groundwater Quality

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This paper outlines the development of the system for controlling groundwater quality in Michigan. The factors influencing the development of the Water Resources Commission General Rules, Part 22. Groundwater Quality, are described. The process by which the rules were developed and major issues encountered are pointed out. Issues covered include: (1) groundwaters to be protected, (2) the basis of protection, (3) the approach to controlling discharges, and (4) the party responsible for determining groundwater quality. The development of a proposal for considering degradation/nondegradation of usable aquifers is also discussed. Problems encountered in developing the proposal and their resolution are discussed. The three major issues addressed by the proposal are: (1) the approach to be taken in dealing with hazardous and non-hazardous materials in a discharge, (2) methods by which to determine degradation/non-degradation and set effluent limits for groundwater discharge permits, and (3) points at which compliance with discharge permits is to be determined.

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DEVELOPMENT OF ADMINISTRATIVE RULES

FOR GROUNDWATER QUALITY

Task 10 of Groundwater Management Strategy for Michigan
Major Funding From Environmental Protection Agency Grant No. P00558801

January, 1982

Michigan Department of Natural Resources
Water Quality Division

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ABSTRACT

This paper outlines the development of the system for controlling groundwater quality in Michigan. The factors influencing the development of the Water Resources Commission General Rules, Part 22. Groundwater Quality, are described. The process by which the rules were developed and major issues encountered are pointed out. Issues covered include: (1) groundwaters to be protected, (2) the basis of protection (3) the approach to controlling discharges, and (4) the party responsible for determining groundwater quality. The development of a proposal for considering degradation/nondegradation of usable aquifers is also discussed. Problems encountered in developing the proposal and their resolution are discussed. The three major issues addressed by the proposal are: (1) the approach to be taken in dealing with hazardous and nonhazardous materials in a discharge, (2) methods by which to determine degradation/nondegradation and set effluent limits for groundwater discharge permits, and (3) points at which compliance with discharge permits is to be determined.

DEVELOPMENT OF ADMINISTRATIVE RULES FOR GROUNDWATER QUALITY

The Groundwater Quality Rules are a necessary element of the Groundwater Management Strategy for Michigan. The rules were promulgated as General Rules of the Water Resources Commission under the Water Resources Commission Act, Act No. 245, Public Acts of 1929. The development of the rules became necessary due to increasing problems with severe groundwater contamination problems. The rules are designed to provide a uniform policy for regulating discharges to groundwater and a uniform approach to the issuance of groundwater discharge permits. Therefore, they are the essential ingredients around which the Groundwater Management Strategy must be designed.

The purpose of this task is to:

(1.) Describe the development of the Rules for Groundwater Quality, General Rules of the Water Resources Commission, R323.2201 to R323.2211, and the recommended Staff Guidance in Considering Degradation/Non-Degradation of Usable Aquifers, including:

  (a.) The impetus for their development
  (b.) The procedure by which they were developed
  (c.) Major issues encountered and their resolution

(2.) Describe the impacts of the Rules for Groundwater Quality and the Degradation/Non-Degradation Guidance on water programs.

(3.) Describe the relationship of the Groundwater Quality Standards and Degradation/Non-Degradation Guidance to other parts of the Strategy.

Background

The development of the Groundwater Quality Standards has been influenced by two major factors. The first of these is the evolution of water pollution control efforts represented in state and federal legislation. The second factor is the growth in knowledge concerning the importance of groundwater supplies and their vulnerability to pollution. Each of these factors was necessary in creating the regulatory precedent and the public knowledge necessary for the acceptance of Groundwater Quality Rules.

By briefly tracing the evolution of state and federal water pollution control legislation, the environment that has made groundwater quality standards possible is discernible. The first major step in controlling water pollution in Michigan was the passage of the Water Resources Commission Act, Act 245, P.A. 1929. As the preamble states, it is "An act to create a water resources commission to protect and conserve the water resources of the state,...(and) to prohibit the pollution of any waters of the state and the Great Lakes..." Over 50 years of water pollution control efforts have made regulation of this sort an accepted activity of state government.

The second major step in making groundwater quality rules possible was taken in 1949. Section 2 of Act 245 was amended further defining the Water Resources Commission's authority. Originally the commission was to have control of all state waters affected by waste disposal. As amended, the commission "shall have control of the

pollution of surface or underground waters of the state." Since this amendment the commission and the Department of Natural Resources have taken many actions to abate groundwater pollution.

The next steps leading to the development of groundwater standards started in 1965 in response to a resolution of the commission to develop surface water quality standards as provided for by Act 245. This resolution in combination with the Federal Water Quality Act of 1965, PL 89-234, giving states the authority to adopt water quality standards for interstate waters, resulted in the promulgation of Michigan's first water quality standards in 1968. The authority to develop these standards had been present in Section 5 of Act 245 since 1929. The acceptance of standards in both theory and practice was then firmly established.

The 1970's served to provide both the final steps toward the development of groundwater quality rules as well as the necessary public awareness of groundwater pollution problems. In response to the passage of the Federal Clean Water Act of 1972, PL 92-500, Act 245, section 5, was amended to give the commission authority to issue permits to regulate all those who discharge or store polluting substances and to set permit restrictions to comply with federal law. Although this amendment was designed largely to give the commission the authority to issue National Pollutant Discharge Elimination System permits by delegation from the federal government, it also served to initiate the development of state groundwater discharge permits. In 1973 a new set of water quality standards was also promulgated.

Through the mid-1970's a series of serious groundwater contamination problems came to light which convinced Michigan government that better controls were needed over the discharge of contaminants to groundwater. Among these problems was the serious pollution of groundwater caused by waste dumping by Hooker Chemical Company at its plant near Montague, Michigan. Domestic wells and White Lake were contaminated by organic chemicals which had seeped into groundwater and traveled off the plant site. In response to the growing alarm over these kinds of problems, the commission directed staff of the Department of Natural Resources to develop rules for groundwater quality so that the commission would be able to use a uniform policy for regulating discharges to groundwater and establish a uniform approach to the issuance of groundwater discharge permits.

Development of the Rules

By tracing the development of the Rules for Groundwater Quality, an understanding of the intent of the rules and the difficulties in implementing them can be gained. In addition, the process by which administrative rules are developed in general is illustrated. The discussion here will first present a description of the promulgation of administrative rules and then proceed to a discussion of the Rules for Groundwater Quality and the major issues encountered in their development.

The procedures by which administrative rules are promulgated are designed to give maximum visibility of the proposed rules to the public. Visibility is ensured not only by the various stages of review, but also by the length of the process. Six basic steps are involved in successfully promulgating rules (see Attachment 1 for the entire process).

1. Preparation of proposed rules by the agency.

2. Review of the proposed rules by the appropriate commission and approval for the purposes of public hearings.

3. Public hearings and revision of proposed rules according to public comment.

4. Review of revised rules by the appropriate commission and transmittal to Joint Legislative Rules Committee.

5. Review and approval of the proposed rules by the Joint Legislative Rules Committee.

6. Adoption and formal promulgation of the rules by the appropriate commission and filing with the Secretary of State.

Each time the proposed rules come before a commission, are presented at public hearings, or are considered by the Joint Legislative Rules Committee the public is provided the opportunity to influence the nature of the rules. In addition, at any time a commission or the Rules Committee considers the rules, the rules can be sent back to some earlier point in their development.

The Groundwater Quality Rules went through the rule promulgation process in a fairly representative manner. Their development was initiated in July, 1976, and the rules were officially promulgated August, 1980 (see Attachment 2 for the chronology of their development). The proposed rules were initially developed by a staff committee with representatives from the Department of Natural Resources and the Department of Public Health. The following discussion will point out some of the major issues encountered during the development of the rules and how these issues influenced the timing of the development process.

The rules development committee faced certain problems that were to haunt the rules throughout their development and create considerable delays before their final promulgation. First, no guidance existed in the form of groundwater standards in other states or in the form of national standards or strategy. Therefore, each decision made by the committee was breaking new ground. Some of the major questions facing the committee included:

1. Which groundwaters should be protected?

2. What should the basis of this protection be?

   a. Existing groundwater quality?

   b. Some standard set by rule?

   c. Background groundwater quality unaffected by a discharge?

3. What should the approach to dischargers be?

   a. Zero discharge of pollutants?

   b. Nondegradation - discharges of pollutants at concentrations existing naturally in groundwater?

   c. Reasonable use - change in groundwater concentrations of parameters in discharge of specified amounts?

   d. Some combination of the above?

4. Who should be responsible for determining groundwater quality?

   (See Attachment 3 for the final form of the Groundwater Quality Rules.)

The remainder of this discussion will point out major issues which were raised by rule.

Rules 2202 & 2203. Definitions

The definitions used were modified and improved fairly smoothly through the first half of the development process. By December, 1978, they had reached their final form. One major change was made at this time that is crucial to the philosophy of the standards and their implementation. The definition of "degradation", R2202(g), was modified from "...a deterioration of ground water quality within any portion of a usable aquifer system, the deterioration being identified by a change in ground water quality from local background ground water quality" to "...a change in ground water quality from local background ground water quality within any portion of a usable aquifer system, which is determined by the commission to be a deterioration in terms of the magnitude of the change and the importance of the parameters describing groundwater quality" and the definition of deterioration, R.2202(h), added. This change provided for greater flexibility in determining when degradation has taken place and emphasizes the philosophy that changes in the constituents of groundwater and their concentrations can take place without necessarily being degradation. Also, the change allows that a reasonable use of groundwaters be made with respect to some parameters in a discharge and zero discharge of others. However, the question is raised on how the commission will determine deterioration. In fact, one of the comments at the April, 1979, public hearing suggested that the definition was too restrictive and that degradation be defined as deterioration of groundwater quality which precludes the uses of the aquifer for which it is protected. The commission chose to stay with the more restrictive definition.

Rule 2205. Nondegradation of Ground Waters in Usable Aquifers

The Nondegradation Rule is crucial to the Groundwater Quality Rules. This rule describes the basis on which the quality of Michigan's groundwater resources will be protected. The rule has been accepted with little change since its development by the rules committee, but several criticisms have been presented. Among the criticisms are:

1. The rule should have numerical criteria for included parameters.

2. Existing background groundwater quality should be used as a basis for determining nondegradation instead of local background groundwater quality.

3. Nondegradation should be a goal, not a requirement.

4. The rule could have an adverse impact on the capability of municipalities and others to use land disposal of sludges and wastewater.

Although each of the above comments is legitimate, the first three were not incorporated into the standards. Numerical criteria are not practical due to the wide variability in groundwater quality. Such a list would never be complete. Existing groundwater quality was not used as the basis for determining degradation since in many cases this would mean that a presently degraded aquifer then becomes the criteria for protection and surrounding aquifers or surface waters could then be threatened. Nondegradation is a requirement, not a goal, because the rules must be enforceable.

The fourth comment, which concerns land application, is the most difficult with which to deal. The standards do not prohibit the disposal of sludges and wastewater by land application, but, depending on the commission's decision on whether activities of this nature cause degradation, many applicants could be denied permits or forced to pursue variances under R.2210. The decision on this issue is still to be completely clarified.

Rule 2206. Regulation of Discharges

This rule is one of the two rules which created a lengthy delay in the promulgation of the rules. In December, 1978, the Attorney General returned the rules to the commission in part because R.2206 was worded in such a way that it appeared as if other units of government could issue a permit. Originally, the rule read as follows:

> Discharges into groundwaters of the state are regulated by permits issued in accordance with sections 7(1) and 8(b) of the act, or by approval, permit, or license from other units of government in accordance with established policies and the rules of the commission.

The portion underlined was deleted although it appears to be a reference to R.2209, Activities not Requiring a Permit. Only the commission has the authority to issue a permit. This change plus a change to the variance rule, R.2210, precipitated a return to public hearings in April, 1979.

Some commentors felt that the new standards would increase the number of permits necessary and, therefore, the costs of groundwater protection born by the public. Since permits are required by Act 245, however, this should not be the case. The standards should improve the administration and effectiveness of permits, though.

Rule 2207. Hydrogeological Report
Rule 2208. Monitoring

Comments on rules 2207 and 2208 largely concerned the expense that dischargers would incur complying. The costs of compliance were pointed out as being very substantially less than the cleanup of contaminated groundwaters.

Rule 2210. Variances

The variance rule has illicited more comment and controversy than any other portion of the rules. Comments have ranged from stating that the rule is too weak to stating that it is too strong. For instance, the following comments were received in the 1977 public hearing process:

1. Variances should never be allowed. No degradation is acceptable.

2. Variances allowing complete degradation should be available on economic justification.

3. There should be variances allowing reasonable degradation that present a health hazard.

The responses to these comments have helped set the tone of groundwater quality protection in Michigan. First, some provision should be made for exceptional cases. The benefits of allowing a discharge could outweigh the cost of some groundwater degradation, and the variance rule allows for a demonstration that such is the case. The public health, safety, and welfare must be protected, however. Therefore, no variances would be issued for discharges which could cause such a hazard.

A major change took place in the variance rule in response to the Attorney General review of December, 1978. The change in this rule plus the change in the permit rule, R.2206, resulted in new public hearings being held in April, 1979. The original variance rule allowed for two types of variances. The first type was for "reasonable" degradation. If it could be demonstrated to the commission that the degradation did not preclude the use of the aquifer for its protected uses and would not become injurious to the public health, safety, or welfare, a permit issued in accordance with Act 245 would constitute a variance. The second type would allow degradation of any aquifer to the extent that the protected uses were precluded. "Such variances may be granted by the commission for exceptional circumstances determined by the commission that strict conformity with R232.2205 is not economically or technically feasible and no prudent alternative exists..." In these cases the discharger must "affirmatively" demonstrate the need for a variance.

The variance for "reasonable" degradation was rejected by the Attorney General since all permits could then be interpreted as variances. The rule as originally written would create confusion about when a nondegradation permit was issued and when a variance was issued. In addition, no criteria were set forth in the rules by which the commission would grant a permit for "reasonable" degradation in one case or require a variance of a different type in another except that the protected uses could be undertaken in one case and not the other. Therefore, justification of its actions would be difficult for the commission. In order to correct this problem, the variance rule was rewritten deleting the reference to permits by dropping variances for "reasonable" degradation and deleting the references to protected uses. By making these changes, all requests for discharges that could not be issued nondegradation permits would be judged under the same criteria.

Other Issues

Two other issues were of importance in the development of the standards. The Rules for Groundwater Quality which were taken to public hearings in September, 1977, contained a rule which was subsequently deleted in its entirety. This was the liability rule. One of the most serious difficulties in dealing with groundwater contamination is determining who is liable for correcting the problem. The rule assigned liability to the property owner and transferred liability to each subsequent property owner. It also required that permits to discharge to the groundwater be recorded on the deed. Comments at the public hearings and from the Attorney General indicated that the rule exceeded the authority under Act 245. The rule was deleted, therefore, but assigning liability for contamination is still a major issue for the State of Michigan in its efforts to implement remedies to contamination incidents.

After the April, 1979, public hearing, the rules moved smoothly to the final hurdle before final promulgation, the Joint Legislative Rules Committee. This final review helps to assure that the rules comply with the legislative intent and also provides the public with a final say on the new rules through their elected representatives. As is evident from Attachment 2, the Chronology of Development, the committee had enough concerns of its own and received enough negative input from other sources to require the Department of Natural Resources to withdraw the rules from committee consideration before the 60 day time period for committee action elapsed. By working with committee members over the intervening period, final approval of the rules was accomplished in June, 1980.

The final promulgation of the Rules for Groundwater Quality was a significant step forward in the efforts to protect Michigan's water resources. The standards have provided a uniform policy for regulating discharges to groundwater and the basis for a uniform approach to the issuance of groundwater discharge permits. One major issue is still in need of clarification before a uniform approach to issuing permits can be implemented, however. This issue involves the further clarification of the definition of degradation for the purposes of developing the effluent limits to be included in permits. This need has resulted in the development of the Recommended Staff Guidance in Considering Degradation/Nondegradation of Usable Aquifers.

Development of the Recommended Staff Guidance in Considering Degradation/Nondegradation of Usable Aquifers

Soon after the promulgation of the Groundwater Quality Rules, staff of the Department of Natural Resources realized that the rules did not give sufficient guidance to determine effluent limits for groundwater discharge permits. Staff, therefore, was directed to develop the numerical guidelines necessary for administering the rules and for making reasoned, consistent recommendations for discharge permits. Recommendations on the issuance or denial of permits are made to the Water Resources Commission since the commission has no staff of its own and has the sole authority to issue or deny a permit. The key to developing the guidance is the definition of degradation, R. 2202(g).

> "Degradation" means a change in ground water quality from local background ground water quality... which is determined by the commission to be a deterioration in terms of the magnitude of the change and the importance of the parameters describing ground water quality.

Therefore, the objective of developing the guidance was first to determine what magnitude of change in groundwater quality would be a deterioration and second to identify the importance of various parameters.

A task force with members from the Water Quality Division, Geological Survey Division, and the Environmental Services Division of the Department of Natural Resources and the Water Supply Division of the Department of Public Health was formed to develop the guidance. The task force met weekly from March through June of 1981 and presented the guidance to the Water Resources Commission on an informational basis in September, 1981 (See Attachment 4 for the present form of the guidance). The following discussion will describe how the task force dealt with three major issues:

1. Approach to be taken in dealing with hazardous and nonhazardous parameters in a discharge.

2. Methods by which to determine degradation/nondegradation, and set effluent limits for groundwater discharge permits.

3. Points at which compliance with discharge permits is to be determined.

Hazardous Materials

A major issue of discussion throughout the life of the task force was how to regulate discharges of hazardous materials to groundwater. Questions arising over their regulation included:

1. Should any discharge of hazardous materials be allowed?

2. If a discharge is allowed, what is an acceptable level of risk at which to regulate hazardous materials in the discharge?

3. To what extent is the state of the art in analytical techniques going to influence regulation?

4. How will the decision be made on what materials will be regulated as hazardous?

1. Two opinions can be formed from the rules concerning the allowance of toxic or hazardous materials in discharges to groundwater. A case for zero discharge can be developed based on the definition of "degradation", the nondegradation rule, R.2205, and the variance rule, R.2210. If hazardous parameters are judged as being of sufficient importance, then degradation would occur regardless of their concentrations in a discharge. Therefore, in order to comply with the nondegradation rule, a hazardous material could not be discharged. Further support for this position is found in the variance rule which states:

> A variance shall not be granted under this rule for discharges containing hazardous materials in amounts or concentrations which singly or in combination pose an unacceptable, existing, or potential risk to human health or the environment.

This rule can be interpreted as saying that if the discharge of hazardous materials is not allowed under a variance, hazardous materials should not be allowed in discharges with nondegradation permits.

An equally convincing case can be made for allowing discharge of hazardous materials at some level, however. Since degradation is "determined by the commission", it does not have to mean zero discharge. In addition, hazardous materials are defined as "those substances that...pose an unacceptable... risk to human health or to the environment..." Therefore, acceptable levels of risk could be allowed. The variance rule also specifies "unacceptable" risks. Each interpretation is equally valid. The task force chose to interpret the rules in the less strict sense for the purposes of the guidance. This would not constrain staff from recommending zero discharge of certain parameters in a permit, though, on a case by case basis.

2. Expertise exists within the Department of Natural Resources for calculating acceptable levels of risk to a human when exposed to toxic or hazardous materials. Draft procedures have been developed for determining human life cycle safe concentrations of chemicals in groundwater (See Attachment 4, Appendix C). The human life cycle safe concentration (HLSC) is the highest concentration of a chemical to which a human if exposed continuously for a lifetime, results in no observable adverse effects to this individual or his progeny. The task force decided that groundwater should be managed so that concentrations of hazardous materials in groundwater should not exceed the HLSC for noncarcinogens. For carcinogens, the concentration representing the $1x10^{-6}$ risk factor was selected as an appropriate management level. The concentrations so derived would be used as standards and concentrations of hazardous materials should not be allowed to exceed these levels in a usable aquifer due to a discharge.

This approach raises two further questions. Should effluent limits in permits be set at the HLSC or the $1x10^{-6}$ risk factor or at some portion of these concentrations? What position should be taken if background groundwater quality already exceeds these concentrations? The task force adopted

the position of allowing the discharge to contain a concentration of a hazardous parameter at some level below the HLSC or $1x10^{-6}$ risk level. This position was adopted for at least three reasons. First, the nondegradation rule, R.2205, states that the quality of groundwater shall not be degraded from local background groundwater quality. By selecting the standard as the basis for regulating groundwater, background groundwater quality is ignored. Therefore, regulation should be based on some comparison of background and the standard. Second, if a discharge is allowed at the standard, further discharges of that parameter downgradient in the aquifer could be eliminated, depending on the source of water supply of additional dischargers. Third, scientific knowledge supporting the human life cycle safe concentration or the $1x10^{-6}$ risk level changes over time. A concentration which appears to be an acceptable risk today may prove to be unacceptable due to increased knowledge of risks uncovered in future research. By setting effluent limits below the standard, an additional safety component is incorporated into the permit above those included in the computation of the standard.

Another consideration involves developing effluent limits for chemicals for which insufficient data exists to calculate a HLSC or $1x10^{-6}$ risk concentration. The decision here was to allow discharges at background groundwater quality concentrations until adequate information on the chemical is available.

In many cases, however, maximum concentrations of chemicals in water for various uses have been adopted by agencies such as the Environmental Protection Agency. The data considered by the task force included EPA primary drinking water standards, EPA national livestock water standards, and Academy of Science crop irrigation water standards. The task force decided that:(1) the most restrictive standard be used for determining effluent limits, (2) a previously adopted standard for a parameter be used even if it was not as restrictive as an HLSC or $1x10^{-6}$ risk factor, (3) a more restrictive standard could be adopted if staff can support it, and (4) an HLSC or $1x10^{-6}$ risk factor be calculated for chemicals not covered by such standards.

3. The state of the art in analytical techniques has a very definite impact on the regulation of hazardous materials in groundwater. A standard, HLSC, or $1x10^{-6}$ risk factor can easily result in a nondegradation level concentration which is below the level of detectability using existing analytical techniques. Therefore, three alternatives are available for the regulation of such chemicals:

   (a) Set limits at the level of detectability, essentially resetting the standards at that concentration.

   (b) Allow use of the chemical as long as its concentration in the discharge is not detectable.

   (c) Prohibit discharges which have contacted such a chemical.

   Since alternatives (a) and (b) do not provide what the task force considered an acceptable level of protection for groundwater users, alternative (c) was selected.

4. A list of hazardous materials and their standards was developed by the task force. The task force proposed that at least once a year a committee formed of representatives from the Departments of Public Health, Agriculture, and Natural Resources meet to review the chemicals included on the list and their standards and revise the list as necessary. Until the official changes were made, staff would request interim standards on chemicals not included on the list from technical staff on a case by case basis.

Nonhazardous Materials

The regulation of nonhazardous materials in discharges to groundwater presents fewer difficulties than that of hazardous materials. In most cases, the decision on an allowable concentration of such a material in a discharge will depend on the magnitude of change from background groundwater quality which it will cause. Standards do exist for nonhazardous materials, but, in general, they are based on aesthetic considerations such as taste, odor, or color rather than health effects, e.g., EPA secondary drinking water standards. Since in many cases the background groundwater quality of Michigan aquifers exceeds the standards, the secondary standards have not been proposed as maximum concentrations for usable aquifers. In cases where background concentrations are low compared to the standard, the quality of the aquifer should be protected, however.

Determination of Degradation/Nondegradation

The task force developed a very specific process for applying the definition of degradation to a discharge to groundwater which will determine when a discharge causes degradation. To be acceptable this process must take into consideration three factors:

(a) Background groundwater quality - This is the basis for groundwater regulation as stated in the Nondegradation Rule, R.2205.

(b) The standard for a parameter - The maximum concentration to be allowed in a usable aquifer.

(c) Amount of change - The degree to which the concentration of a parameter in background groundwater quality will be changed by the discharge.

Items (a) and (c) are used to determine the magnitude of the change from background water quality while item (b) indicates the importance of the parameter.

The use of a mathematical formula of some sort was felt to be the most concise method of making determinations of degradation or nondegradation. In addition, this would engender greater consistency among the range of staff which participate in the development of discharge permits. The first proposal was very straight forward and involved calculating an acceptable level of increase from background water quality for a particular parameter.

$Y = c(B)$ or $Y = c(S)$, whichever is greater

Where Y = an acceptable level of increase in concentration from background groundwater quality for a parameter

c = a constant for a parameter

B = concentration of a parameter in background groundwater

S = an acceptable maximum concentration for a parameter in a usable aquifer such as found in drinking water standards.

The formula Y = c(S) does not take background groundwater quality into account, however. Since background quality is the basis for regulation in the standards the following formula was proposed.

$$Y = c(S-B)$$

This formula would yield negative concentrations when (B) is larger than (S) which is the case for nonhazardous materials in many parts of Michigan. This problem was overcome easily as follows.

$$Y = c|S-B|$$

The method for determining the Non Degradation Level (NDL) of a parameter in a discharge as adopted by the task force is:

$$NDL = Y+B = c(B)+B$$

$$NDL = Y+B = c|S-B|+B$$

where

NDL = nondegradation level of a parameter

Y = allowable change in the concentration of a parameter

c = constant for a parameter

B = existing background groundwater quality concentration for a parameter

S = the accepted standard for a parameter

Both of these formulas should be applied and the highest concentration resulting from the calculations should be used as the NDL and as the effluent limit for a parameter in the permit.

An important point of discussion for the task force was the selection of an appropriate (c) value. The decision was made to use (c) = (0.1) initially until adequate experience was gained with the guidance to determine appropriate (c) values for specific parameters. The (c) values would then be officially adopted and periodically reviewed by the same committee of Natural Resources, Agriculture and Public Health representatives that would deal with standards (S) for hazardous materials.

Compliance Points

Once the nondegradation levels for the parameters contained in a groundwater discharge are determined and included in a permit as effluent limits, the question remains on where they are measured in order to determine compliance with a permit. The task force agreed that a conservative approach should be applied while giving the discharger the option of demonstrating the viability of less conservative approaches. The two basic compliance points should be:

(1.) At the point of discharge for hazardous materials. The nondegradation level for all hazardous parameters must be met before the discharge enters the ground.

(2.) At the point where the discharge enters the usable aquifer. If the discharger can demonstrate that soil treatment or some other mechanism will alter the nature of hazardous materials in the discharge for the life of the discharge, then the compliance point can be established where the discharge enters the usable aquifer. This is also the compliance point for nonhazardous materials.

A significant portion of the discussion on compliance points was concerned with whether an allowance should be made for dispersion and diffusion of discharged materials as they move through the usable aquifer. The major questions discussed included:

(1.) Does any dispersion and diffusion occur during the movement of a discharge plume in an aquifer?

(2.) Should the entire flow of an aquifer be available for such calculations or only some percentage of it?

The task force consulted experts in the modeling of pollutant movement through aquifers to augment the hydrogeologic expertise on the task force for the solutions to these questions. The following conclusions were reached:

(1.) The science of modeling contaminant movement in groundwater is not well developed and provides little guidance in making a regulatory decision.

(2.) Existing knowledge indicates that little dispersion and diffusion of contaminants takes place in aquifers.

(3.) The entire flow of an aquifer would be needed to make the consideration of such a mechanism worthwhile for regulatory purposes.

The task force decided that provision should be made in the guidance for a compliance point which allows for consideration of dispersion and diffusion. However, due to the inexactness of modeling, certain safeguards have been built in. First, this approach applies only to nonhazardous materials. Second, in order to provide adequate response time if model predictions are incorrect, the flow time to the property boundary of the fastest moving parameter in the discharge must be at least two years. The compliance point in this case can be 1/2 the distance to the property boundary or the distance traveled in two years, whichever is most restrictive. In order to be eligible for such a compliance point, the discharger must demonstrate that the nondegradation level will be met at the compliance point for each parameter using dispersion and dillusion calculations based on acceptable computer modeling or other analytical techniques.

Implications

The Task Force Recommendations for Staff Guidance in Considering Degradation/Nondegradation of Usable Aquifers has significant implications for the Groundwater Management Strategy and the management of Michigan's water resources. The recommendations take a step beyond the groundwater quality rules by applying a more specific definition to "degradation" in addition to setting up a clear cut procedure for establishing the effluent limits for groundwater discharge permits. Such guidance would be a very effective tool for establishing consistency among staff in making recommendations to the Water Resources Commission on whether a discharge will cause degradation and whether a permit should be issued. The recommended guidance does appear to make the decision making process somewhat inflexible, however, and the use of constant(c) in the formulas has received considerable comment. Questions on both its scientific and legal supportability have been received. Such questions have put the implementation of the recommended guidance in doubt.

The recommended guidance can have a substantial impact on the Groundwater Management Strategy for Michigan also. Tasks within the strategy which will be influenced by the guidance include:

Task 5: Monitoring - The guidance determines the locations of compliance monitoring wells.

Task 6: Draft Decision Matrix - Certain decision making steps are highlighted due to the existence of the guidance.

Task 10: Groundwater Quality Standards - The work on the guidance is part of this task.

Task 12: Permits and Licenses - The form of the permit system depends on procedures set forth in the guidance.

Task 13: Facility Design, Siting, Treatment, and Operation - Permits developed under the guidance would substantially influence decisions on these items.

Task 14: Compliance and Enforcement - The guidance provides procedures for developing compliance levels and points.

Task 20: Groundwater Modeling - The guidance raises questions on contaminant movement which may be answered here.

Task 21: Final Groundwater Management Strategy - The guidance would be an integral part of the final strategy.

Whatever decision is made on the system which staff will use in making degradation/nondegradation recommendations to the Water Resources Commission, it will deal with many of the issues pointed out in this paper. The recommended guidance describes a workable decision making process in general, if not specifically, and lays a firm foundation for further work.

ATTACHMENT 1

Promulgation of Administrative Rules

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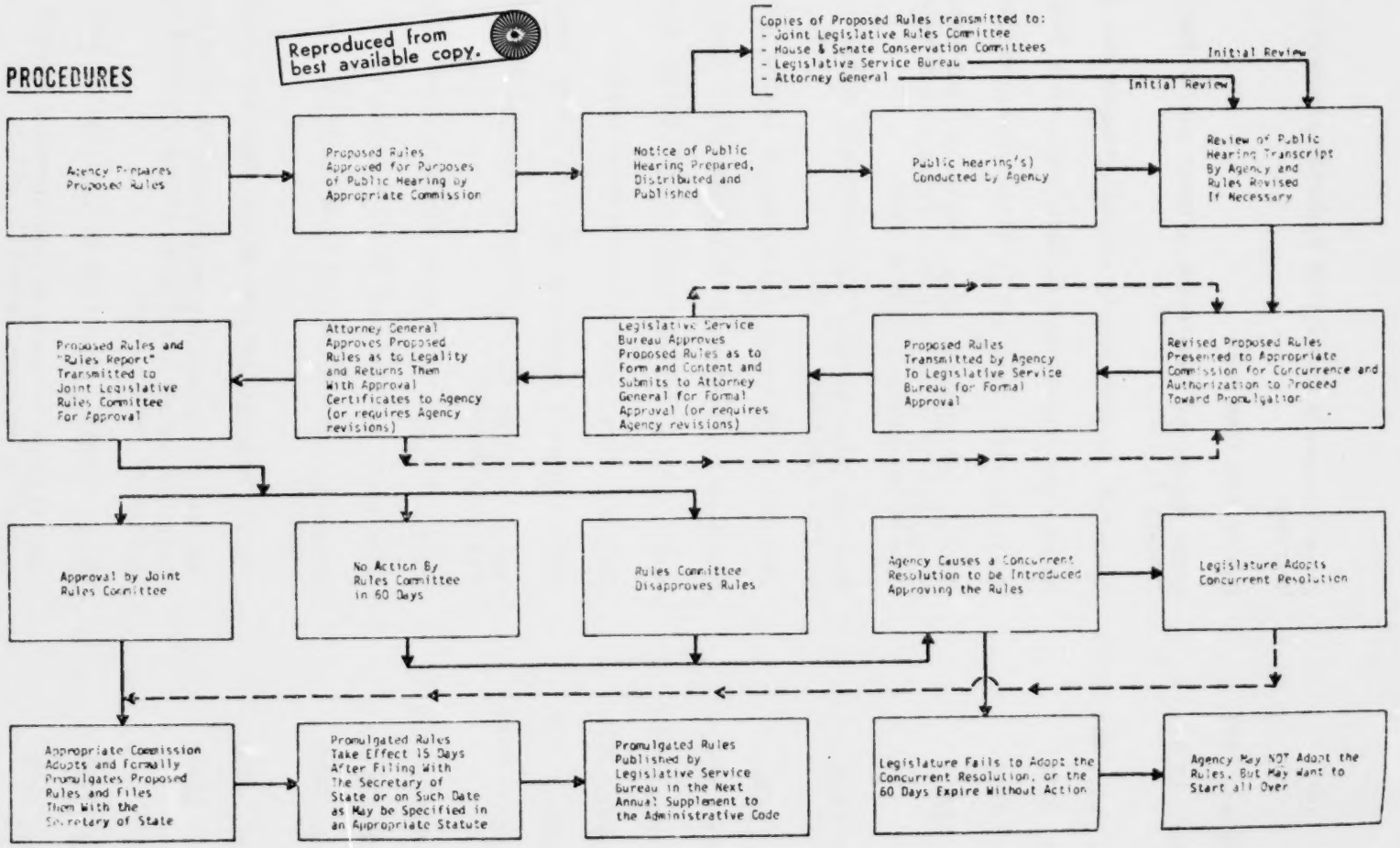
PROCEDURES
Agency Prepares Proposed Rules
Proposed Rules Approved for Purposes of Public Hearing by Appropriate Commission
Notice of Public Hearing Prepared, Distributed and Published
Copies of Proposed Rules transmitted to:
- Joint Legislative Rules Committee
- House & Senate Conservation Committees
- Legislative Service Bureau
- Attorney General
Initial Review
Initial Review
Public hearing(s) Conducted by Agency
Review of Public Hearing Transcript By Agency and Rules Revised If Necessary
Revised Proposed Rules Presented to Appropriate Commission for Concurrence and Authorization to Proceed Toward Promulgation
Proposed Rules Transmitted by Agency To Legislative Service Bureau for Formal Approval
Legislative Service Bureau Approves Proposed Rules as to Form and Content and Submits to Attorney General for Formal Approval (or requires Agency revisions)
Attorney General Approves Proposed Rules as to Legality and Returns Them With Approval Certificates to Agency (or requires Agency revisions)
Proposed Rules and "Rules Report" Transmitted to Joint Legislative Rules Committee For Approval
Approval by Joint Rules Committee
No Action By Rules Committee in 60 Days
Rules Committee Disapproves Rules
Agency Causes a Concurrent Resolution to be Introduced Approving the Rules
Legislature Adopts Concurrent Resolution
Appropriate Commission Adopts and Formally Promulgates Proposed Rules and Files Them With the Secretary of State
Promulgated Rules Take Effect 15 Days After Filing With The Secretary of State or on Such Date as May be Specified in an Appropriate Statute
Promulgated Rules Published by Legislative Service Bureau in the Next Annual Supplement to the Administrative Code
Legislature Fails to Adopt the Concurrent Resolution, or the 60 Days Expire Without Action
Agency May NOT Adopt the Rules, But May Want to Start all Over

ATTACHMENT 2
GROUNDWATER RULES
CHRONOLOGY OF DEVELOPMENT

July, 1977	Water Resources Commission approves proposed rules for public hearings
September, 1977	Public hearings held
October, 1977	Water Resources Commission extends public hearing record to January 1, 1978
Jan., Feb., Mar. 1978	Committee reviews public record comments and proposed changes
March, 1978	Rules report presented to Water Resources Commission
April, 1978	Revised draft presented to Water Resources Commission
May, 1978	Changes requested by Water Resources Commission included and presented to Water Resources Commission. Water Resources Commission adopts proposed rules
June, 1978	Michigan Environmental Review Board reviews rules and submits written questions
July, 1978	Response to Michigan Environmental Review Board questions
August, 1978	Michigan Environmental Review Board approves proposed rules
September, 1978	Rules informally submitted to Legislative Services Bureau
November, 1978	Response from Legislative Services Bureau
December, 1978	Rules formally submitted to Legislative Services Bureau
December, 1978	Rules approved by Legislative Services Burea/submitted to Attorney General
December, 1978	Rules returned by Attorney General/changes required
March, 1979	Committee develops modifications required
March, 1979	Proposed rules submitted to Water Resources Commission for approval
April, 1979	Public hearings held at Water Resources Commission meeting
June, 1979	Review public hearing record with Water Resources Commission Water Resources Commission adopts proposed rules for continuation of rules making
July, 1979	Rules formally submitted to Legislative Services Bureau
July, 1979	Legislative Services Bureau approved revised rules and submitted to Attorney General's office
September, 1979	Attorney General's office approves rules

September, 1979	Submitted to Joint Rules Committee
October 16, 1979	Hearing before Joint Rules Committee → Tabled
October 23, 1979	Hearing before Joint Rules Committee → 4 yes/4 no; rules withdrawn
June 24, 1980	Joint Rules Committee approves rules
July, 1980	Rules to Water Resources Commission for formal adoption
July 30, 1980	Rules to Executive Office for transmittal to Secretary of State
August 14, 1980	Rules filed at Secretary of State
August 29, 1980	Rules take effect

ATTACHMENT 3

DEPARTMENT OF NATURAL RESOURCES

WATER RESOURCES COMMISSION

GENERAL RULES

Filed with Secretary of State on August 14, 1980. These rules take effect 15 days after filing with the Secretary of State.

(By authority conferred on the water resources commission by sections 2 and 5 of Act No. 245 of the Public Acts of 1929, as amended, being §§ 323.2 and 323.5 of the Michigan Compiled Laws)

The General Rules of the water resources commission are amended by adding R 323.2201 to R 323.2211 to read as follows:

PART 22. GROUND WATER QUALITY

R 323.2201. Purpose; scope.

Rule 2201. (1) The purpose of the ground water quality rules is to protect the public health and welfare and to maintain the quality of ground waters in all usable aquifers for individual, public, industrial, and agricultural water supplies.

(2) These rules provide for the nondegradation of ground water quality in usable aquifers, define the requirements for hydrogeological study before permitting a discharge into ground waters, establish ground water monitoring requirements for new and existing ground water discharges, and establish a procedure for obtaining variances from these rules.

R 323.2202. Definitions; A to N.

Rule 2202. As used in this part:

(a) "Act" means Act No. 245 of the Public Acts of 1929, as amended, being § 323.1 et seq. of the Michigan Compiled Laws.

(b) "Aquifer" means underground water-bearing earth materials through which ground water moves in sufficient quantity to serve as a source of water supply.

(c) "Aquifer system" means a single aquifer or a series of interconnected aquifers of local or regional extent.

(d) "Change in ground water quality" means a true difference in ground water quality at a site that is considered by the commission to be a true difference, from one point in time to another, after considering the seasonal and locational variation of quality within a site.

(e) "Commission" means the water resources commission.

(f) "Controlled application" means the proper application of a chemical for its intended purpose.

(g) "Degradation" means a change in ground water quality from local background ground water quality, within any portion of a usable aquifer system, which is determined by the commission to be a deterioration in terms of the magnitude of the change and the importance of the parameters describing ground water quality.

(h) "Deterioration" means an impairment of water quality or its value.

(i) "Diffuse source" means any facility or operation which transmits material by seepage or percolation through the soil to the ground waters.

(j) "Discharge" means the addition of materials to ground waters from any facility or operation which acts as a discrete or diffuse source and which requires a permit to discharge pursuant to the act.

(k) "Discrete source" means any facility or operation which transmits materials to the ground waters by a discernible confined conveyance.

(l) "Domestic waste" means wastes generated and discharged as a result of normal household activities.

(m) "Existing ground water quality" means concentrations of the physical, biological, chemical, and radiological parameters representative of the ground water quality in usable aquifers at a site at the time of permit issuance, permit renewal, or nonpermitted discharge as determined by the hydrogeological study required by rule 2207.

(n) "Ground water" means underground water within the zone of saturation.

(o) "Hazardous material" means those substances that, singly or in combination, pose an unacceptable, existing, or potential risk to human health or to the environment because they may be flammable, explosive, reactive, corrosive, toxic, radioactive, infectious, carcinogenic, bioconcentrative, persistent, or irritating when present in sufficient concentrations.

(p) "Hydrogeological determination" means the collection, interpretation, and presentation of hydrologic and geologic data to provide an adequate understanding of existing conditions and to determine the potential impact on the ground waters of a discharge from an operation or activity.

(q) "Industrial waste" means waste from industrial or manufacturing processes, or from a trade or business, as distinct from domestic or sanitary waste.

(r) "Local background ground water quality" means concentrations of the physical, biological, chemical, and radiological parameters representative of the ground water quality in usable aquifers at a site having virtually no influence by discharges as determined by the hydrogeological study required by rule 2207.

(s) "Monitoring well" means a well that is specifically designed to measure the impact of a discharge on the ground waters.

(t) "Non-contact cooling water" means water used for cooling which does not come into direct contact with any raw material, intermediate product, by-product, waste product, or finished product.

R 323.2203. Definitions; O to W.

Rule 2203. As used in this part:

(a) "Observation well" means a well that is specifically designed to determine existing hydrogeological conditions.

(b) "Parameters" means those specific characteristics describing the physical, chemical, biological, and radiological conditions of the ground water quality.

(c) "Person" means an individual, partnership, association, corporation, industry, municipality, state agency, or interstate body.

(d) "Radioactive materials" means natural or synthetic materials which give off particles or rays, or both, from nuclear reactions whereby the particles or rays pose an unacceptable, existing, or potential risk to human health or to the environment.

(e) "Sanitary waste" means treated or untreated wastes that contain human metabolic wastes and domestic wastes.

(f) "Sludge" means concentrated residues generated or produced by industrial activities or by the treatment of industrial or sanitary wastes.

(g) "Solid waste" means refuse, garbage, rubbish, ashes, or other materials in solid form.

(h) "Toxic material" means a substance that is or may become harmful to plant life, animal life, or to food chains when the substance is present in sufficient concentrations or combinations.

(i) "Usable aquifer" means an aquifer, or that portion of an aquifer or aquifer system, that is capable of providing water in sufficient quantity and of satisfactory quality, as determined from the hydrogeological study required by rule 2207, to serve 1 or more protected uses. Usable aquifers do not include aquifers used for mineral, oil, or gas production, as regulated by Act No. 315 of the Public Acts of 1969, as amended, being §319.211 et seq. of the Michigan Compiled Laws, and known as the mineral well act, and Act No. 61 of the Public Acts of 1939, as amended, being §319.1 et seq. of the Michigan Compiled Laws, the act which regulates oil and gas in Michigan.

(j) "Well" means a properly designed and constructed hydraulic structure that permits measurement or withdrawal of ground water from an aquifer.

R 323.2204. Protected uses.

Rule 2204. All ground waters of the state, in usable aquifers and of a quality suitable for use as individual, public, industrial, or agricultural water supply, shall be protected for these uses.

R 323.2205. Nondegradation of ground waters in usable aquifers; permissible and prohibited discharges.

Rule 2205. (1) The quality of ground waters in all usable aquifers shall not be degraded from local background ground water quality as the result of a discharge, except as provided in rule 2210.

(2) Discharges into ground waters may be made, consistent with the requirements of the act and applicable rules, if necessary measures are taken to prevent the degradation of ground waters in usable aquifers. The following are such measures:

(a) Proper waste water treatment.

(b) Proper facility site selection.

(c) Controlling the zone of saturation at the site.

(d) Providing percolation and seepage barriers.

(e) Use of underdrainage.

(f) Containment of the discharge within the boundaries of the operation or activity defined by the hydrogeological study required by rule 2207.

(3) Materials at concentrations that exceed the maximum contaminant levels for inorganic and organic chemicals specified in the national interim primary drinking water regulations, 40 C.F.R. §§141.11 and 141.12, which are promulgated pursuant to the safe drinking water act 42 U.S.C. §300f, shall not be discharged into ground waters in usable aquifers even in those cases where the local background ground water levels for these materials exceed the specified levels.

R 323.2206. Regulation of discharges.

Rule 2206. A person shall not discharge into the ground waters any substance that is, or may become, injurious to the public health, safety, or welfare, or to the domestic, commercial, industrial, agricultural, recreational, or other uses which are being or may be made of the ground waters. Discharges into ground waters of the state are regulated by permits issued in accordance with sections 7(1) and 8(b) of the act.

R 323.2207. Determination of existing hydrogeological conditions; report.

Rule 2207. (1) A determination of existing hydrogeological conditions or study, including existing ground water quality, shall be made in the vicinity of proposed or existing discharges.

(2) The person responsible for the discharge shall provide the hydrogeological study.

(3) At each discharge site, at least 1 hydrogeological study, or its equivalent, shall be required to develop the discharge permit.

(4) For existing permitted discharges, a hydrogeological study, or its equivalent, shall be required at the time of permit renewal when an approved or presently acceptable hydrogeological study is not available. The continued permitting of an existing discharge shall be contingent on satisfactory hydrogeological conditions at the site, as determined by the hydrogeological study. The commission shall provide sufficient time for the hydrogeological study to be developed by the person responsible for the discharge.

(5) The following are the purposes of a hydrogeological study:

(a) To establish the impact that a discharge may have on ground water contained in usable aquifers.

(b) To determine, through interpretation of available and collected data, the acceptability of discharging at the site.

(c) To determine existing ground water quality.

(d) To determine local background ground water quality.

(e) To define engineering modifications that may make the discharge acceptable.

(f) To define a proposed ground water monitoring program.

(g) To define the usable aquifers.

(h) To define the areal and vertical extent of the site earth materials that assimilate and transmit the discharge.

(6) The acceptance of a site shall be determined on the basis of the hydrogeological study and consideration of proper engineering modifications.

(7) One of the following criteria shall be considered in determining whether an aquifer is usable:

(a) Whether an aquifer is presently serving a protected use.

(b) Whether an aquifer, as defined by the hydrogeological study, can potentially serve the protected uses.

(c) Whether a well can be constructed in the aquifer meeting the requirements of part 127 of Act No. 368 of the Public Acts of 1978, as amended, being §333.12701 et seq. of the Michigan Compiled Laws, an act relating to water well drilling, and Act No. 399 of the Public Acts of 1976, as amended, being §323.1001 et seq. of the Michigan Compiled Laws and known as the safe drinking water act.

(8) Hydrogeological studies shall be prepared by or under the direction of a qualified ground water or engineering geologist or a registered professional engineer with assistance from experts in related fields, such as land surveying, environmental science, and soil science.

(9) Determination of hydrogeological conditions shall cover sufficient area to allow for a definition of the impact of the discharge on ground water in a usable aquifer. The determination shall take into account the local geology and the surface and ground water conditions, including water quality parameters specific to each site. The following minimum elements shall be required in determining the impact of the discharge on ground water in usable aquifers:

(a) The concentrations of the following water quality parameters shall be determined at each site:

(i) Specific conductance as an indication of the dissolved solids.

(ii) Determination of the concentration of the following parameters for chemical balance and indicators for comparison of water quality:

Cations	Anions
Calcium	Chloride
Sodium	Sulfate
Magnesium	Bicarbonate

(b) Additional ground water quality parameters may be required. These additional parameters shall be selected by the commission on a case-by-case basis if the parameters can be justified on the basis of any 1 of the following criteria:

(i) The parameters may cause degradation in usable aquifers and are present or likely to be present in the discharge.

(ii) The parameters can demonstrate that a discharge to a usable aquifer is occurring.

(iii) The parameters can be used to define the existing or local background ground water quality.

(c) The following categories include examples of some of the parameters that may be required in addition to the minimum parameters specified in subrule 9(a) of this rule:

(i) Industrial wastewater: chemical oxygen demand, metals, organic compounds, hazardous, and toxic materials.

(ii) Industrial sludge: chemical oxygen demand, metals, organic compounds, hazardous, and toxic materials.

(iii) Municipal wastewater: nitrite nitrogen, nitrate nitrogen, ammonia nitrogen, total phosphorus, metals, methylene blue active substances.

(iv) Municipal sludge: nitrite nitrogen, nitrate nitrogen, ammonia nitrogen, total phosphorus, metals, methylene blue active substances.

(v) Sanitary landfills: total iron, chemical oxygen demand, nitrite nitrogen, nitrate nitrogen, ammonia nitrogen, metals, hazardous, and toxic materials.

(d) A map of the site and surrounding area drawn to scale showing the distance to existing wells and the properties in the surrounding area having potential for groundwater supplies; existing lakes or ponds; streams, springs, and swamps; direction of surface drainage and the direction of ground water movement in the site area; locations of borings, observation wells, and other well data used in the determination, shall be provided. Wells used in making ground water quality determinations shall be identified.

(e) Sufficient water well records. Observation wells or borings shall be required to determine the composition of subsurface earth materials in order to locate usable aquifers and to establish the degree of connection with the discharge.

(f) Sufficient data or not less than 3 observation wells shall be required to determine the ground water flow direction and possible variations plus the depth to the ground water and possible variations in depth. The top of the well casings shall be referenced to a common or United States geological survey datum.

(g) Evaluation of site earth materials shall be made to determine the ability of these earth materials to assimilate, by physical, chemical, or biological means, the various constituents of the discharge.

(h) Evaluation of the ability of the site earth materials to percolate and transmit the volume of liquids resulting from the discharge shall be made.

(i) The nature, extent, and consequence of mounding resulting from the discharge that can be anticipated to occur above the highest naturally occurring water table may be required.

(j) A description of the proposed engineering modifications that will ensure control of the discharge shall be provided for those discharges that may degrade water quality in usable aquifers.

(k) A determination of the horizontal and vertical flow system to properly determine the location and depth to be monitored, especially when mounding is superimposed on the existing system, may be required.

(l) A ground water monitoring program shall be proposed, including the design, location, and depth of monitoring wells and the methods of sampling.

(m) Compilation and interpretation of data, maps, and charts based on site conditions to support conclusions and recommendations shall be included with the study.

(10) The Commission shall decide the acceptability of the hydrogeological study or its equivalent. The commission may exclude the requirements of this rule on a case-by-case basis, if the criteria, limitations, or conditions necessary to protect the usable aquifer are met.

R 323.2208. Ground water monitoring.

Rule 2208. (1) Ground water monitoring shall be required for all discharges to assist in the determination of compliance under rule 2211. Ground water monitoring shall include collection of water quality and water level data from a well or group of wells that are specifically designed to adequately assess the impact of any discharge on ground water. The design of the ground water monitoring system shall be based on the hydrogeological study; consideraiton of the local geology, surface water, and ground water conditions specific to each site; and the type of discharge. These factors shall determine the number of locations, number of wells at each location, and depth of each well.

(2) Monitoring wells shall be located and completed at depths as specified in the hydrogeological study so as to intercept any discharge from the site to ground water contained in a usable aquifer.

(3) Monitoring well design and construction elements shall include the following criteria:

(a) The drilling method shall be specified.

(b) Monitoring wells completed in fine-textured earth materials shall have special construction, such as gravel packing around the screen.

(c) Monitoring wells shall have suitable equipment and methods for sampling ground water, as specified in the hydrogeological study.

(d) Construction of monitoring wells shall be by a water well driller registered under Act No. 294 of the Public Acts of 1965, as amended, or a contractor regulated by Act No. 315 of the Public Acts of 1969, as amended. Monitoring well construction shall be as specified in the approved hydrogeological study.

(e) Casings shall be installed so as to prevent vertical leakage of fluids between the casing and the drill hole, and shall be capped and provided with a cap locking device. Use of a vented cap is desirable but care shall be taken to prevent introduction of contaminants through such vents.

(f) The well casing shall be protected against accidental damage and shall be adequately marked so as to be clearly visible during winter and summer conditions.

(g) Each well shall be labeled and identified by the owner's name, owner's address, the well number, the use of well, and a warning.

(h) When a monitoring well is to be permanently abandoned, approved plugging procedures shall be followed as provided in Act No. 294 of the Public Acts of 1965, as amended, or by Act No. 315 of the Public Acts of 1969, as amended.

(4) The person responsible for a discharge shall provide for the design, installation, and operation of the ground water monitoring system.

(5) The commission shall decide the acceptability of the ground water monitoring system. The commission may exclude the requirements of this rule on a case-by-case basis, if the criteria, limitations, or conditions necessary to protect the usable aquifer are met.

R 323.2209. Activities not requiring a hydrogeological report, ground water monitoring, and discharge permits.

Rule 2209. (1) The following activities do not require a permit from the commission or a hydrogeological report or ground water monitoring, except as may be required by the commission on a case-by-case basis, where such activities are or may become injurious to the protected uses of a usable aquifer:

(a) Disposal of sanitary wastes in volumes of less than 10,000 gallons per day through the use of septic tank and ground disposal systems approved by local county and district health departments that are certified by the commission.

(b) Controlled application of dust-suppressant chemicals used with normally accepted or regulated practices.

(c) Controlled application of de-icing chemicals used with normally accepted or regulated practices.

(d) Controlled chemical applications for natural resource and right-of-way programs used with normally accepted or regulated practices.

(e) Controlled application of chemicals for domestic purposes used with normally accepted or regulated practices.

(f) Controlled application of chemicals for agricultural and silvicultural use by normally accepted or regulated practices.

(g) Disposal of non-contact cooling water, not treated by the addition of chemicals, in volumes established at the discretion of the commission.

(h) Retention of storm water runoff in surface impoundments or surface waterways.

(2) Other activities may be excluded as determined by the commission on a case-by-case basis, if the criteria, limitations, or conditions that the commission deems necessary are met.

R 323.2210. Variances.

Rule 2210. (1) Variances from the requirements of rule 2205 may be granted by the commission.

(2) Variances may be granted by the commission for exceptional circumstances where it is determined by the commission that strict conformity with rule 2205 is not economically or technically feasible, that a prudent alternative does not exist, and that such variance is consistent with the promotion of the public health, safety, and welfare in light of the state's paramount concern for the protection of its natural resources.

(a) A variance shall not be granted under this rule for discharges containing hazardous materials in amounts or concentrations which singly or in combination pose an unacceptable, existing, or potential risk to human health or the environment.

(b) In granting variances under this rule, the commission shall prescribe such criteria, limitations, or conditions as the commission deems necessary to protect the public health of present or future ground water users affected by the variances. Such conditions shall include preventing the degradation of ground water in other usable aquifers, prescribing treatment techniques, or providing an alternate approved water supply.

(c) All variances granted by the commission under this rule shall require a discharger or proposed discharger to the waters of the state to affirmatively demonstrate the need for a variance in terms of the criteria specified in this subrule.

(d) Before granting a variance under this rule, the commission shall provide for adequate public notice and opportunity for public hearing.

(3) Variances granted under this rule to dischargers required to be permitted by the commission pursuant to the requirements of the act shall be reviewed by the commission at the time of permit reissuance.

R 323.2211. Determination of compliance.

Rule 2211. (1) The Commission shall determine compliance with these rules on the basis of all reports and information available.

(2) In making tests or analyses of water or waste to determine compliance with the rules, samples shall be collected in such a manner that the location, number, and frequency are considered satisfactory by the commission. The samples shall be preserved and analyzed pursuant to procedures outlined in 40 C.F.R. §136.1 et seq., promulgated pursuant to section 304(g) of the federal water pollution control act, as amended, 33 U.S.C. §1314, or analyzed pursuant to 40 C.F.R. §141.1 et seq., promulgated pursuant to section 1401(1) of the safe drinking water act, 42 U.S.C. §300f which are herein adopted by reference, or pursuant to other methods prescribed or approved by the commission. Copies of 40 C.F.R. §136.1 et seq. and 40 C.F.R. §141.1 et seq. are available at a cost of $2.25 from the Department of Natural Resources, P.O. Box 30028, Lansing, Michigan 48909, and from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

June 29, 1981

DRAFT

Subject to Revision

ATTACHMENT 4

TASK FORCE RECOMMENDATIONS FOR STAFF GUIDANCE IN CONSIDERING DEGRADATION/NON-DEGRADATION OF USABLE AQUIFERS

In order to consistently evaluate wastewater discharge applications for land disposal, with respect to groundwater degradation, staff from the Department of Public Health, Water Supply Division, and the Department of Natural Resources, Water Quality and Geological Survey Divisions have developed numerical guidelines which are intended to form the basis of permit recommendations to the Water Resources Commission. These guidelines represent the Task Force's majority consensus.

"Degradation" as stated in Part 22 Rules has the following definition:

> "R323.2202 (g) 'Degradation' means a change in ground water quality from local background groundwater quality, within any portion of a usable aquifer system, which is determined by the Commission to be a deterioration in terms of the magnitude of the change and the importance of the parameters describing ground water quality."

Because of the non-specificity of this definition, the charge of the Task Force was to determine a practical method of defining groundwater changes that generally do not result in "degradation" that can guide the Commission in its determinations. Therefore, in order to remain within the spirit and intent of the Part 22 Rules, the Task Force dissected the given definition and considered first, an acceptable "magnitude of change" in groundwater quality that would generally not result in degradation and second, the parameters that would be important or significant. (The Task Force utilized, as much as possible, the definitions in Part 22 Rules).

In addressing the magnitude of change in groundwater quality, the Task Force recommends that, in general, a ten percent (10%) change from background groundwater quality be considered significant. More specifically, the Task Force recommends that two equations be used by staff to determine the recommended amount of allowable change in quality.

EQUATION I:

$y = c(B)$ where y = allowable change
c = constant (10%)
B = existing background groundwater quality for a specific parameter

suggests a ten percent (10%) change from background quality be considered non-degradation.

EQUATION II:

$y = c|S-B|$ where y = allowable change
c = constant (10%)
B = existing background groundwater quality for a specific parameter
S = the accepted standard for the specific parameter

suggests a ten percent (10%) change in the difference between the accepted standard and the background quality for a specific parameter be considered non-degradation.

The Task Force feels that both equations fulfill the intent of the Part 22 Rules in that background groundwater quality is a major controlling factor for any allowable change in groundwater quality. In Equation I, background groundwater quality is the primary factor controlling change; application of this formula simply allows a ten percent (10%) change from all background groundwater quality (regardless of a standard, but with some restrictions to be discussed). In Equation II, change in quality is controlled by the accepted standard for a particular parameter and by the background groundwater quality; basically allowing more change in better quality water and less change as the standard is approached. (Greater change may also be allowed with poorer quality water, but with some exceptions to be discussed).

Once the general concept was established as to the magnitude of change that should be allowed, the Task Force applied the concept to specific classes of parameters. The following guidance expands the equations into two formulas to reflect the maximum acceptable concentration in an usable aquifer, and it details the specific applications, qualifications, and limitations of the two formulas.

The maximum level to which background groundwater concentrations may be increased in an usable aquifer will be referred to as the Non-Degradation Level (N.D.L.). The concentration (N.D.L.) of a parameter to which local background groundwater quality may be changed is represented by the following two formulas:

FORMULA I: $N.D.L. = y+B = c(B)+B$

FORMULA II: $N.D.L. = y+B = c|S-B|+B$

B = "local Background groundwater quality" as defined in Part 22 Rules "means concentrations of the physical, biological, chemical, and radiological parameters representative of the ground water quality in usable aquifers at a site having virtually no influence by discharges as determined by the hydrogeological study required by Rule 2207."

S = The most restrictive standard or criteria for an usable aquifer as provided by Tables I and II of Appendix A. Once a year, or as needed, a list of parameters, their respective "S" values, and procedures will be reviewed for update by the Departments of Agriculture, Public Health, and Natural Resources.

c = constant = 0.1 Once a year, or as needed, the list of "c" values will be reviewed for update by the Departments of Agriculture, Public Health, and Natural Resources.

y = $c(B)$ or $c|S-B|$ = maximum allowable change from local background groundwater quality

The N.D.L. must be complied with at the discharge outfall or at the points where the discharge enters the usable aquifer. To establish the compliance points where the discharge enters the usable aquifer, the discharger must demonstrate that the soil or other mechanism can continuously (i.e. for the expected life of the discharge) modify all the discharge parameters to the N.D.L. prior to entering the usable aquifer. The two formulas would be applied to two groups of parameters--hazardous and non-hazardous--in the following manner:

HAZARDOUS MATERIALS (as defined in Part 22 Rules)

Whichever of the two formulas allows the larger increase from local background groundwater quality, will be the formula used to establish the N.D.L. for a parameter. For hazardous materials, the N.D.L. shall not exceed the

established standard for a specific parameter. (See examples in Appendix B). The compliance point for hazardous materials shall be at the points that the discharge enters the usable aquifer.

1. The Human Lifecycle Safe Concentration (HLSC) will be used for "S" in the formula for non-carcinogens. (See Appendix C). A 10^{-6} risk level for carcinogens will be used as 'S' in the formula.

Modifiers to this approach are listed below:

a) An involuntary level of risk other than that determined above, that is already adopted or endorsed by Michigan shall be used to establish the standard (S) in the formula unless a more restrictive level can be defended by the Department of Natural Resources;

b) When the HLSC, N.D.L. or 10^{-6} risk level for a hazardous material is less than the limit of detectability (based on best technology available) discharges that have contacted that material shall not be allowed;

c) For discharge parameters for which no HLSC or carcinogenic risk level has been or can be established, no discharge greater than local background groundwater quality will be allowed to the usable aquifer until sufficient information is available for staff to determine a standard (S);

d) An organoleptic (taste and odor) or color criteria will be used for "S" if more restrictive.

2. Usable aquifers protected for uses in addition to or other than human consumption may have additional "S" values that apply to respective uses; in this case, the most restrictive "S" will be used in the formulas.

NON-HAZARDOUS MATERIALS (All materials other than hazardous)

The same general approach used for hazardous materials is recommended with the exception that the accepted standard (S) may be exceeded. Again, the larger value yielded by the two formulas is considered non-degradation.

In some cases, use of this approach will allow the N.D.L. to exceed existing "secondary" standards. Parameters covered by Secondary Drinking Water Standards affect such things as odor, corrosivity, and general nuisance.

Compliance points for non-hazardous parameters shall be at the points that the discharge enters the usable aquifer. However, if the discharge can demonstrate that the travel time in the usable aquifer of the fastest moving discharge parameter is two years or greater from the edge of the discharge area to the property bondary, then the compliance points shall be located at one-half the distance to the property boundary or at the distance traveled in two years, whichever is most restrictive. The demonstration used by the discharger must include dispersion and diffusion calculations using acceptable computer modeling or other analytical techniques. In addition, the discharger must show that all non-hazardous parameters discharged will meet the non-degradation level at the compliance point.

When there is no standard (S), background level (B) or constant (c) for a non-hazardous material, a standard (S) and constant (c) should be developed as needed by agreement of the Departments of Agriculture, Public Health, and

Natural Resources. Until such standard (S) and constant (c) is developed, staff may develop an interim discharge limit governing that parameter. See examples in Appendix B.

SUPPLEMENTAL TASK FORCE RECOMMENDATIONS:

A discharger shall not be allowed to degrade the groundwater on his property except in very restricted circumstances. A variance would be required for this type of action. Furthermore, we recommend that this type of variance be accompanied by appropriate legal notation on the property description or by a deed declaration to indicate to future owners that groundwater at this site may have been degraded from local background groundwater quality.

APPENDIX A
TABLE I
PARTIAL LIST OF NON-HAZARDOUS PARAMETER STANDARDS (S)*

PARAMETER	STANDARD	SOURCE
Bicarbonate, HCO_3	crop and soil dependent	
Chloride, Cl	250 mg/l	US EPA Secondary Drinking Water Standards
Iron, Fe	0.3 mg/l	US EPA Secondary Drinking Water Standards
pH	6-9 range for surface water natural groundwater ranges from 7-8	
MBAS	0.5 mg/l	US EPA Secondary Drinking Water Standards
Manganese	0.05 mg/l	US EPA Secondary Drinking Water Standards
Sulfate, SO_4	250 mg/l	US EPA Secondary Drinking Water Standards
Total Dissolved Solids	500 mg/l	US EPA Secondary Drinking Water Standards
color	15 color units	US EPA Secondary Drinking Water Standards
odor	3 threshold odor numbers	US EPA Secondary Drinking Water Standards
Sodium, Na	270 mg/l	Recommended maximum for individuals on a moderate restricted sodium diet

*This list is only intended to be a partial listing of non-hazardous parameters. Additional standards for other specific parameters may be obtained from the DNR.

APPENDIX A
TABLE II
PARTIAL LIST OF HAZARDOUS PARAMETER STANDARDS (S)*

PARAMETERS	STANDARD	SOURCE
Acenaphthene	6300 ug/l	HLSC Procedure
Aluminum, Al	5 mg/l	US EPA-National Livestock Water Standards
Arsenic, As	0.05 mg/l	US EPA Primary Drinking Water Standards
Barium, Ba	1.0 mg/l	US EPA Primary Drinking Water Standards
Benzene	0.68 ug/l	10^{-6} Risk Factor **
Benzidine	0.00015 ug/l	10^{-6} Risk Factor **
Beryllium, Be	0.1 mg/l	Academy of Science, Crop Irrigation Water Standard
Boron, B	0.75 mg/l	Academy of Science, Crop Irrigation Water Standard
C56	0.2 ug/l	HLSC Procedure
Cadmium, Cd	0.01 mg/l	US EPA Primary Drinking Water Standards
Carbaryl	0.35 mg/l	HLSC Procedure
Carbon Tetrachloride	0.42 ug/l	10^{-6} Risk Factor **
Chloroform Bromodichloromethane Dibromochloromethane Bromoform	100 ug/l (total of 4)	US EPA Primary Drinking Water Standards
Chromium, Cr	0.05 ~~0.10~~ mg/l	Primary Drinking Water Std Academy of Science, Crop Irrigation Water Standard
Cobalt, Cb	0.05 mg/l	Academy of Science, Crop Irrigation Water Standard
Copper, Cu	0.2 mg/l	Academy of Science, Crop Irrigation Water Standard
Fluoride, F	1 mg/l	Academy of Science, Crop Irrigation Water Standard
Endrin	0.2 ug/l	US EPA Primary Drinking Water Standards
Lead, Pb	0.05 mg/l	US EPA Primary Drinking Water Standards

APPENDIX A
TABLE II (con't.)

PARAMETERS	STANDARD	SOURCE
Lindane	4.0 ug/l	US EPA Primary Drinking Water Standards
Lithium, Li	2.5 mg/l	Academy of Science, Crop Irrigation Water Standards
Manganese, Mn	0.2 mg/l	Academy of Science, Crop Irrigation Water Standards
Mercury, Hg	0.002 mg/l	US EPA Primary Drinking Water Standards
Molybdenum, MO	0.01 mg/l	Academy of Science, Crop Irrigation Water Standards
Nitrogen-Nitrate, NO_3-N	10 mg/l	US EPA Primary Drinking Water Standards
Nitrogen-Nitrite, NO_2-N	10 mg/l	US EPA-National Livestock Water Standards
Methoxychlor	100 ug/l	US EPA Primary Drinking Water Standards
PCB	0.0081 ug/l	10^{-6} Risk Factor**
PCE	~~0.8~~ 0.88 ug/l	10^{-6} Risk Factor**
Phenol	300 ug/l	U.S. EPA Organoleptic Criteria
Radiological: gross alpha	15 pCi/l	US EPA Primary Drinking Water Standards
combined radium 226 radium 228	5 pCi/l	US EPA Primary Drinking Water Standards
beta particle photon radio activity	4 millirems/yr	US EPA Primary Drinking Water Standards
Selenium, Se	0.01 mg/l	US EPA Primary Drinking Water Standards
Silver, Ag	0.05 mg/l	US EPA Primary Drinking Water Standards
Total Coliform	0/100 ml	State of Michigan Drinking Water Standards
Trichloroethylene	2.78 ug/l	10^{-6} Risk Factor**

APPENDIX A
TABLE II (con't.)

PARAMETERS	STANDARD	SOURCE
1,1,2,2 tetrachloroethane	0.17 ug/1	10^{-6} Risk Factor**
Toxaphene	5 ug/1	US EPA Primary Drinking Water Standards
2, 4-D	100 ug/1	US EPA Primary Drinking Water Standards
2,4,5-TP (silvex)	10 ug/1	US EPA Primary Drinking Water Standards
Vanadium, V	0.1 mg/1	US EPA-National Livestock Water Standards
Zinc, Zn	2 mg/1	Academy of Science, Crop Irrigation Water Standards

*This list is only intended to be a partial listing of hazardous parameters. Additional standards for other specific parameters may be obtained from the DNR.

**10^{-6} derived by the Office of Toxic Materials Control, Environmental Services Division, MDNR.

APPENDIX B

The examples in Appendix B show the application of Formulas I and II to calculate the concentrations of materials that can be discharged directly to an usable aquifer. These concentrations are the non-degradation level (N.D.L.) of these materials. The N.D.L. is the concentration that can be permitted via a non-degradation permit in compliance with Rule 2205. Concentrations in the discharge higher than those stated in the Appendix B examples can be permitted provided the discharger demonstrates that waste treatment, groundwater, and soil above or upgradient of the usable aquifer reduce the concentration to the N.D.L. at the point of entry to the usable aquifer.

An example for hazardous parameters would be the case for 2,4,5-TP. The established standard is 10 ug/l. In the example in Appendix B computed non-degradation levels are shown for four different background groundwater quality situations. The non-degradation levels for each respective background groundwater quality are computed by using Formulas I and II. The concentration or appropriate non-degradation level that may be discharged is the greater value given by the two formulas. Considering two extreme cases where local background groundwater quality has "0" 2,4,5-TP and the second case has 15 ppb 2,4,5-TP. The first case would allow 1 ppb 2,4,5-TP to be discharged to the groundwater. The second case, since the background is already above the accepted standard (S), no discharge greater than 10 ppb (the standard (S)) would be allowed to an usable aquifer. An exception to this case would be if the discharger can demonstrate that a discharge greater than 10 ppb would be modified by some natural mechanism in the soil by the time it reaches the point of entry to the usable aquifer.

An example for non-hazardous parameters would be chloride. For a given standard (S) value of 250 mg/l, the appropriate non-degradation level (N.D.L.) is the greater computed in Formulas I and II. The results are shown for four different local background groundwater quality levels. In the extreme case where the background quality for chloride is 0 mg/l, the N.D.L. is 10% of the standard (S) or 25 mg/l. In another extreme case when the local background groundwater quality is twice the "S" value or 500 mg/l, the N.D.L. allows a slight increase over background or 550 mg/l. This demonstrates that consideration is given to an adopted standard (S) when it is available and when the local background groundwater quality would have prohibited any discharge. Conversely, because the local background quality controls the amount of change for Michigan, when the local quality is poorer than an arbitrary "S" value, the local background groundwater quality sets the N.D.L. and allows an increase to 550 mg/l as the N.D.L.

APPENDIX B

EXAMPLES OF HAZARDOUS PARAMETERS

Parameter	Standard (S)	Background GW Quality (B)**	Constant (c)	Change from Bkgr GW Qual. y=c(B)	Change from Bkgr GW Qual. y=c|S-B|	Non-Degradation Level (N.D.L.) =c(B)+B	Non-Degradation Level (N.D.L.) =c|S-B|+B
2,4,5-TP (silvex)	10 ppb	0	.1	0	1 ppb	0	*1
		2 ppb	.1	.2 ppb	.8 ppb	2.2 ppb	*2.8
		9 ppb	.1	.9 ppb	.1	*9.9	9.1
		15 ppb	.1	1.5	.5	16.5	15.5
						Max NDL =10 ppb*	Max NDL =10 ppb*
Lead	50 ppb	0	.1	0	5	0	*5 ppb
		10 ppb	.1	1 ppb	4 ppb	11	*14
		40 ppb	.1	4	1	*44	41
		50 ppb	.1	5 ppb	0	55 ∴	50*
						Max NDL =50 ppb*	
Trichloroethylene	2.78 ppb	0	.1	0	0.28	0	*.28
		1	.1	.1	0	Max NDL =1.1	*1.18
		5	.1	.5	.22	5.5	5.22 ∴
						Max NDL =2.78ppb*	2.78ppb*
X	(?) Unknown ∴ Assume 0	0	.1	0	0	0	0

*Maximum N.D.L. for the indicated parameter and background

**Local background groundwater quality as defined in Part 22 Rules means concentrations of the physical, biological, chemical, and radiological parameters representative of the ground water quality in usable aquifers at a site having virtually no influence by discharges as determined by the hydrogeological study required by Rule 2207.

APPENDIX B
EXAMPLES OF NON-HAZARDOUS PARAMETERS

Parameter	Standard (S)	Local Bkgr GW Quality (B)**	Constant (c)	Change from Bkgr GW Quality		Non-Degradation Level N.D.L.	
				y=c(B)	y=c |S-B|	=c(B)+B	=c |S-B| +B
Chloride or Sulphate	50 ppm	0	.1	0	25	0	*25
		10	.1	1	24	11	*34
		240	.1	24	1	*264	241
		500	.1	50	25	*550	525
Iron	.3	0	.1	0	.03	0	*.03
		.1	.1	.01	.02	.11	*.12
		.3	.1	.03	0	*.33	.30
		.5	.1	.05	.02	*.55	.52
TDS	500 mg/l	100	.1	10	40	110	*140
		400	.1	40	10	*440	410
		800	.1	80	30	*880	830

*Maximum N.D.L. for the indicated parameter and background

**Local background groundwater quality as defined in Part 22 Rules means concentrations of the physical, biological, chemical, and radiological parameters representative of the ground water quality in usable aquifers at a site having virtually no influence by discharges as determined by the hydrogeological study required by Rule 2207.

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APPENDIX C

Derivation of Life Cycle Safe Concentration for Groundwater

The life cycle safe concentration (LSC) is the highest concentration of a chemical to which an organism is exposed continuously for a lifetime, and which results in no observable adverse effects to this organism and its progeny. Depending on the extent of the existing data base for a chemical, different procedures will be used for deriving the LSC.

In determining LSCs for chemicals, the OTMC recognizes that these values should be derived from a complete and accurate toxicological data base. For those chemicals having extensive data bases, LSCs will preferentially be derived from well conducted chronic toxicity studies. However, there exists a large number of chemicals for which there are little or no toxicological data available. Furthermore, to develop an extensive data base for these chemicals could take many years of costly testing. Faced with this situation, the OTMC has developed procedures to derive LSCs from not only chronic bioassays, but also from subacute and acute toxicity test results. The method of extrapolation from subacute and acute toxicity tests to long term chronic safe levels (i.e. LSCs) involves the use of "application factors". An application factor is a numerical value by which the acute or subacute toxicity is adjusted to give a chronic value which provides adequate environmental protection (LSC).

The application factor approach used by the OTMC in deriving LSCs from subacute and acute toxicity data relies on the assumption that the data base used to calculate the application factor is a representative sampling of data from all types of toxicants. An examination of the separate toxicological data bases on fish, macroinvertebrates, and mammals for ratios of chronic no adverse effect level to subacute or acute values reveals a wide range of ratio values. The markedly different ratios are presumably due to many factors such as variation in cumulative toxic effect (highly lipophilic substances; progressive enzyme inhibition), variations in slopes of dose-response curves (i.e. range of sensitivity within a species for a specific toxicant), variation in the mechanism of acute and chronic toxicity, and the variation of specific parameters used to determine the no observable adverse effect level. A further examination of the ratio data will show an approximation of a log-normal frequency distribution, as with most ratio data sets. If the ratios are then serially arranged from largest to smallest, assigned a percentile rank (smallest ratio = 100%), and graphically plotted (ratio vs. percentile rank) on log-probit graph paper, construction of a best fit straight line will allow for the determination of the ratio theoretically giving the 95th percentile rank of all similarly selected and plotted ratios.

Such a ratio (or application factor) when multiplied by any randomly selected, or newly generated subacute or acute toxicity value will give a chronic NOAEL equivalent to, or less than, the true chronic NOAEL for that toxicant 95% of the time. The appropriateness of this level of protection for human health concerns is subject to debate,

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and like an "acceptable" level of risk, a value judgment. Should an alternative level of protection be desired, any number of ratio values may be easily selected by selecting the percentile rank commensurate with the desired level of protection.

OTMC has assembled two data sets of ratios and their percentile ranks which will facilitate the derivation of LSCs. They are: chronic NOAEL/subacute toxicity ratios for rats (Table 1); and chronic NOAEL/acute LD50 ratios for rats (Table 2). Figures 1 and 2 show the log-probit plots and 95th percentile extrapolations of data presented in the corresponding tables.

The OTMC recognizes that there are a number of uncertainties in trying to estimate an LSC from acute toxicity data. Thus, estimates of LSCs from acute data do not represent the value expected from doing an acutal chronic bioassay, and LSCs derived from acute toxicity studies may be more or less restrictive than values derived from actual chronic data. A summary of methods used to derive LSCs follows in the tables and figures.

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DERIVATION OF THE HUMAN LIFE CYCLE SAFE CONCENTRATION (HLSC)

IN GROUNDWATER FOR THE PROTECTION OF HUMAN HEALTH

The human life cycle safe concentration (HLSC) is the highest concentration of a chemical to which a human is exposed continuously for a lifetime, and which results in no observable adverse effects to this individual and its progeny. Depending on the extent of the existing data base for a chemical, different procedures will be used for deriving the HLSC. In determining HLSCs for chemicals, the OTMC recognizes that these values should be derived from a complete and accurate toxicological data base. For those chemicals having extensive data bases, HLSCs will preferentially be derived from well conducted chronic toxicity studies.

I. To derive the HLSC for protection of human health, determine the maximum milligrams of toxicant (MgT) which results in no adverse effects in humans when ingested daily on a chronic basis. This value may be determined by one of the following methods (methods listed in order of preference; proceed to subsequent method if lacking necessary data). The scientific validity of federal standards will be assessed, based on current data base, prior to use in calculations.

1. MgT calculated from National Interim Primary Drinking Water Resulations.

   A. Data needed for this method:

      i. Maximum Contaminant Level (MCL).

      ii. Volume of water consumed daily by humans (Vw = 2 1).

   B. Equation for this method:

      MgT = MCL (mg/1) x 2 1

2. MgT calculated from known chronic human exposures tc toxicant contaminated drinking water:

   A. Data needed for this method:

      i. No observed adverse effect level from chronic exposure to contaminated drinking water (NOAEL).

      ii. Uncertainty factor (U = 10).

      iii. Volume of water consumed daily by humans (V_W = 2 1).

   B. Equation for this method:

      $$MgT = \frac{NOAEL\ (mg/1) \times 2\ 1}{10}$$

3. MgT calculated from Food and Drug Administration regulations:

   A. Data needed for this method:

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i. Acceptable daily intake (ADI)

B. Equation for this method:

$MgT = ADI$

4. MgT calculated from lifetime exposure of mammalian test animal to toxicant contaminated drinking water.

A. Data needed for this method:

i. NOAEL from chronic exposure to contaminated drinking water.

ii. Volume of water consumed daily by test animal (V_W).

iii. Weight of test animal (W_A).

iv. Weight of human (W_H = 70 kg).

v. Uncertainty factor (U = 100).

B. Equation for this method:

$$MgT = \frac{\text{NOAEL (mg/l)} \times \frac{V_W}{W_A} \times 70 \text{ kg}}{100}$$

5. MgT calculated from lifetime exposure of mammalian test animal to toxicant contaminated feed.

A. Data needed for this method:

i. NOAEL from chronic exposure to contaminated feed.

ii. Daily feed consumption expressed as fraction of animal's body weight (C).

iii. Weight of human (W_H = 70 kg).

iv. Uncertainty factor (U = 100).

B. Equation for this method:

$$MgT = \frac{\text{NOAEL (ppm)} \times C \times 70 \text{ kg}}{100}$$

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6. MgT calculated from lifetime exposure of mammalian test animal to toxicant by gavage.

   A. Data needed for this method:

      i. NOAEL from chronic oral dosing.

      ii. Fraction of days dosed per week (F_W).

      iii. Weight of human (W_H = 70 kg).

      iv. Uncertainty factor (U = 100).

   B. Equation for this method:

$$MgT = \frac{\text{NOAEL (mg/kg)} \times F_W \times 70\text{kg}}{100}$$

7. MgT calculated from subacute (~90 day) exposure of rat to toxicant contaminated drinking water.

   A. Data needed for this method:

      i. NOAEL from subacute exposure to contaminated drinking water.

      ii. Volume of water consumed daily by rat (V_W = 0.049 1).

      iii. Weight of rat (W_A = 0.350 kg).

      iv. Weight of human (W_H = 70 kg).

      v. Uncertainty factor (U = 100 or 1000)

   B. Equation for this method:

$$MgT = \frac{\text{NOAEL (mg/l)} \times \frac{0.049\ 1}{0.350\ \text{kg}} \times 70\ \text{kg}}{U}$$

8. MgT calculated from subacute (~90 day) exposure of rat to toxicant contaminated feed.

   A. Data needed for this method:

      i. NOAEL from subacute exposure to contaminated feed.

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ii. Daily feed consumption, expressed as fraction of rat's body weight (C = 0.05).

iii. Weight of human (W_H = 70 kg).

iv. Uncertainty factor (U = 100 or 1000)

B. Equation for this method:

$$MgT = \frac{\text{NOAEL (ppm)} \times 0.05 \times 70 \text{ kg}}{U}$$

9. MgT calculated from subacute (~ 90 day) exposure of rat to toxicant by gavage.

A. Data needed for this method:

i. NOAEL from subacute exposure by gavage.

ii. Fraction of days per week exposed (F_W).

iii. Weight of human (W_H = 70 kg).

iv. Uncertainty factor (U = 100 or 1000)

B. Equation for this method:

$$MgT = \frac{\text{NOAEL (mg/kg)} \times F_W \times 70 \text{ kg}}{U}$$

HLSCs are best derived from data involving oral exposure, since estimating equivalent dose response relationships from other exposure routes adds another element of uncertainty. However, in some cases it may be necessary to use data from exposure routes other than oral. In general, inhalation is the next most relevant, reliably calculable route of exposure. Therefore, the following methods are used for derivation of MgT from inhalation data (methods listed in order of preference).

10. MgT calculated from known chronic human exposures to toxicant contaminated air (i.e. occupational exposure):

A. Data needed for this method:

i. NOAEL from chronic exposure to contaminated air.

ii. Fraction of days exposed per week (F_W).

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iii. Fraction of hours exposed per day (F_D).

iv. Volume of air inspired by human in day (V_A = 20 m^3).

v. Efficiency of absorption of toxicant for inhalation (A_I).

vi. Efficiency of absorption of toxicant from oral exposure (A_O).

vii. Uncertainty factor (U = 10).

B. Equation for this method:

$$MgT = \frac{\text{NOAEL } (mg/m^3) \times F_W \times F_D \times 20\ m^3 \times \frac{A_I}{A_O}}{10}$$

11. MgT calculated from lifetime exposure of mammalian test animal to toxicant in air.

A. Data needed for this method:

i. NOAEL from chronic exposure to contaminated air.

ii. Fraction of days exposed per week (F_W).

iii. Fraction of hours exposed per day (F_D).

iv. Volume of air inspired daily by test animal (V_A).

v. Weight of test animal (W_A).

vi. Weight of human (W_H = 70 kg).

vii. Efficiency of absorption of toxicant from inhalation (A_I).

viii. Efficiency of absorption of toxicant from oral exposure (A_O).

ix. Uncertainty factor (U = 100).

B. Equation for this method:

$$MgT = \frac{\text{NOAEL } (mg/m^3) \times F_W \times F_D \times \frac{V_A}{W_A} \times 70\ kg \times \frac{A_I}{A_O}}{100}$$

12. MgT calculated from subacute (~90 day) exposure of rat to toxicant contaminated air.

A. Data needed for this method:

i. NOAEL from subacute exposure of rat to contaminated air.

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ii. Fraction of days exposed per week (F_W).

iii. Fraction of hours exposed per day (F_D).

iv. Volume of air inspired daily by rat (V_A = 0.223 m^3).

v. Weight of rat (W_A = 0.350 kg).

vi. Efficiency of absorption of toxicant from inhalation (A_I).

vii. Efficiency of absorption of toxicant from oral exposure (A_O).

viii. Weight of human (W_H = 70 kg).

ix. Uncertainty factor (U = 100 or 1000)

B. Equation for this method:

$$MgT = \frac{\text{NOAEL } (mg/m^3) \times F_W \times F_D \times \frac{0.223\ m^3}{0.350\ kg} \times \frac{A_I}{A_O} \times 70\ kg}{U}$$

II. Determine the source of exposure.

Type A: drinking water

III. Derive HLSC for protection of human health.

A. Data needed for this derivation:

i. Maximum milligrams toxicant causing no adverse effects in humans with chronic daily exposure (MgT).

ii. Volume water consumed daily by human (V_W = 2 ℓ)

B. Equation for this derivation:

$$HLSC = \frac{MgT}{2\ \ell}$$

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SUMMARY OF FACTORS AND THEIR QUANTITATIVE VALUES USED IN DERIVING HLSC

FACTOR	QUANTITATIVE VALUE	REFERENCE
V_W (humans)	2 liters	U.S. EPA 1980a
V_A (humans)	20 m^3	U.S. EPA 1980 a
V_W (test animal)	5 ml (mouse) 0.049 l (rat)	Williams 1976 Williams 1976
W_A (test animal)	30 gm (mouse) 350 gm (rat)	U.S. EPA 1980a U.S. EPA 1980a
W_H	70 kg	U.S. EPA 1980a
C	0.13 (mouse) 0.05 (rat)	U.S. EPA 1980a U.S. EPA 1980a
V_A	39 l (30 g mouse) 223 l (350 g rat)	U.S. EPA 1980a U.S. EPA 1980a
U	10; 100; 1,000	N.A.S. 1977

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